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Full Length Research Paper

Determining sucrose recovery in *Saccarrum officinarum* L. using regression and correlation analyses

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Fourteen genotypes of sugarcane, *Saccharium officinarum* (L.), were evaluated for twelve characters and analyzed for genotypic correlation, phenotypic correlation and coefficients of determination were calculated through stepwise regression analysis to construct the regression models for selection of better sugarcane types. High variation was observed for all the characters including sucrose contents. Varying degrees of correlation coefficients were observed, genotypic being of higher magnitude that indicated the genotypic influence for determining a particular trait. Stepwise regression analysis showed the effects of individual characters and the effects in combination contribute the maximum variation (36.0%) to sucrose percentage while two variable model using internodal length and number of tillers plant^{-1} that accounts for maximum variation of 40.1%. Variation for sucrose content on single factor basis was caused by tillers, therefore, this character was the most important to increase overall sucrose of *S. officinarum* L. However, second variable model exhibited that tillers and internodal length were important traits for increasing overall sucrose in sugarcane.

Key words: *Saccharium officinarum*, genotypic correlation, phenotypic correlation, coefficients of determination, Stepwise regression.

INTRODUCTION

Sugarcane is an important food crop of the tropics and sub tropics that is cultivated in more than seventy countries between 40°N and 32° 5´S, encompassing approximately half the globe (FAO, 1998). It is an important cash crop of Pakistan, mainly grown for sugar and sugar-related production. Sugarcane is an important source of income and employment for the farming community of the country. It also forms essential item for industries like sugar, chipboard and paper. Its share in value added of agriculture and GDP are 3.4 and 0.7%, respectively. In Pakistan, sugarcane is grown on 1.099 million ha with average cane yield of 47.32 t ha^{-1} having sugar recovery of 8.74% as compared to world average of 63.7 tones per hectare with sugar recovery as of 10.6% (Anonymous, 2008). Pakistan occupies an important position in cane producing countries of the world and ranks at the fifth position in cane acreage and production and almost 15th position in sugar production that indicated low sucrose recovery. Introduction and multiplication of new promising varieties among the farmers on large scale would surely increase the yield potential and promote the socio-economic development of public and industrial sector as a whole.

Plant breeders are continuously endeavoring to improve the genetic potential of yield and sucrose recovery of this crop so as to meet the demands of an ever increasing population. Several researchers have emphasized the importance of germplasm for utilizing genetic variability either directly or through regression and correlation studies for the selection of better cultivars (Sultana et al., 2007; Ghafoor and Arshad, 2008; Sultana and Ghafoor, 2008). The present study was aimed to determine the role of various parameters through correlation and regression analyses to identify high yielding

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Table 1. Means and analysis of variance for 12 yield and quality traits among 14 genotypes of sugarcane.

Parameter	MS(R)	MS (V)	MS (E)	Mean ± SE	Range	h^2	GA	CV %
Number of tillers	0.17	2.36**	0.33	8.95 ± 0.23	7.3 ± 10	0.60	0.97	6.42
Internodal length	1.27	7.76**	0.497	12.53 ± 0.42	9 ± 14.3	0.78	2.10	5.65
Number of leaves	0.25	9.43**	0.278	26.25 ± 0.41	22 ± 27.9	0.89	2.51	2.04
Plant height (cm)	13.78	1064.28**	84.72	127.14 ± 5.03	93.9 ± 154.3	0.74	23.74	7.24
Leaf area (cm^2)	36983.97	49055.04**	4797.42	888.76 ± 34.16	681 ± 1147	0.69	154.62	7.79
Cane diameter(cm)	0.86	0.59**	0.043	7.37 ± 0.11	6.4 ± 8.42	0.76	0.56	2.81
Sucrose content (%)	0.01	0.49**	0.009	18.03 ± 0.62	10.1 ± 19.34	0.93	0.58	0.51
Brix value (%)	0.01	4.37**	0.009	17.69 ± 0.32	15.34 ± 20.2	0.99	1.83	0.53
Wet weight	0.04	1.32**	0.076	6.47 ± 0.17	5 ± 7.33	0.80	0.87	4.25
Dry matter	0.05	1.50**	0.046	5.60 ± 0.19	4.5 ± 6.5	0.88	0.99	3.89
Cane weight (kg)	0.15	8.07**	0.036	9.23 ± 0.43	6.83 ± 12.12	0.98	2.47	2.06
Juice content (L)	0.01	4.25**	0.006	4.60 ± 0.31	3.16 ± 6.97	0.99	1.8	1.72

and high sucrose genotypes of sugarcane.

MATERIALS AND METHODS

Fourteen sugarcane genotypes (SPF-232, SPF-234, CP-43-33, RB-82-5336, TCP-81-10, CPF-235, CP-72-2086, BF-129, Triton, COL-54, COJ-84, SPSG-26, and COJ-64) along with a standard check (CP-77-400) were planted in a randomized complete block design (RCBD) under field conditions with three replications. Each variety was accommodated in a plot having 4 rows of 000052 m lengths with row to row spacing of 25 cm. All the others agronomic practices were adopted for all the fourteen genotypes during the experiment. Ten guarded plants from each replication were randomly sampled for recording data on plant height (cm), number of tillers per plant, inter-nodal length (cm), number of leaves per plant, leaf area (cm), cane diameter (cm), cane weight (kg), dry matter contents (g), juice content (L), brix value (%) and sucrose content (%). The averaged data thus recorded were analyzed by standard methods for analysis of variance described by Steel and Torrie (1980) using the computer software "MSTATC".

Genotypic and phenotypic correlation coefficients were calculated as outlined by Kwon and Torrie (1964). Standard errors of genotypic correlation coefficients were estimated as given by Lathrop et al. (1985). Coefficients of determination (R^2) were calculated through stepwise regression analysis to construct the regression models for selection of better sugarcane types.

RESULTS

Analysis of variance along with heritability and genetic advance for 14 genotypes indicated significant differences for all the characters under study (Table 1). High variation was observed for all the characters including sucrose contents. The genotype "Triton" is affected by red rot; therefore, it can be used in breeding program or selecting clones with resistant genes. The coefficient of variability (C.V) was in the range from 0.51 to 7.79, which indicated the consistency in experimental conditions. High C.V was observed in leaf area followed by plant height and numbers of tillers were mentioned in. Heritability was higher than 60% for all the parameters (except number of tillers per plant) showing heritable variation among genotypes.

The correlation studies were initiated with the objective of observing the mutual relationship among various characters and also the type and extent of the contribution to yield and sucrose contents (Chaudhary and Joshi, 2005; Panhwar et al., 2003). Genotypic and phenotypic correlation coefficients among twelve characters are presented in the Table 2. The genotypic correlation coefficients reflected that sucrose contents were significantly correlated with internodal length, plant height, leaf area and cane diameter, whereas phenotypic correlation coefficients indicate that sucrose content was positively correlated with all the characters except with number of tillers per plant. Stepwise regression analysis with R-square values showed the effects of every individual characters, the effects of traits in combination and also their percentage contribution towards the internodal length that contribute the maximum variation (36.0%) to sucrose percentage while two variable model using internodal length and number of tillers $plant^{-1}$ that accounts for maximum variation of 40.1%. But the characters like cane diameter, cane weight, wet weight, number of leaves per plant, plant height, brix value, dry matter, leaf area and juice content appeared to be a best combination when R-square value was observed in down ward variable model.

DISCUSSION

Genetic advance (G.A) as percentage of mean for leaf area (cm^2), plant height (cm) and number of leaves was higher showing that these parameters were under the control of additive genes. Singh et al. (1983) reported that numbers of tillers were positively correlated with cane yield. In the present study, internodal length was positive and significantly correlated with number of leaves, plant height, leaf area, sucrose content, brix value, wet weight, dry matter and juice content for genotypic level and for phenotypic level, it was positive and highly significant for number of

Table 2. Genotypic (r_g) and phenotypic (r_p) correlation coefficient among characters of sugarcane accessions

	Inter-nodal length	No. of leaves	Plant height	Leaf area	Cane diameter	Sucrose content	Brix value	Wet weight	Dry matter	Cane weight	Juice contnt
No.of tillers	0.013^{NS} 0.036^{NS}	-0.38^{NS} -0.34*	0.254* 0.211^{NS}	-0.1^{NS} -0.07^{NS}	-0.82^{NS} -0.73**	0.25^{NS} 0.225^{NS}	-0.17^{NS} -0.16^{NS}	-0.04^{NS} -0.05^{NS}	0.277^{NS} 0.239^{NS}	-0.36^{NS} -0.33*	-0.02^{NS} -0.02^{NS}
Internodal length		0.329* 0.314**	0.547* 0.498**	0.561* 0.494**	0.17^{NS} 0.143^{NS}	0.628* 0.6**	0.307* 0.296^{NS}	0.727* 0.679**	0.678* 0.65**	0.036^{NS} 0.037^{NS}	0.38* 0.364*
No. of leaves			0.473* 0.425**	0.399* 0.364*	0.289^{NS} 0.29^{NS}	-0.01^{NS} 0.001^{NS}	-0 -0	-0.286* -0.291^{NS}	0.122^{NS} 0.124^{NS}	0.089^{NS} 0.089^{NS}	0.249* 0.246^{NS}
Plant height				0.652* 0.605**	-0.09^{NS} -0.9^{NS}	0.451* 0.42**	0.127* 0.124	0.449* 0.38*	0.466* 0.432**	-0.08^{NS} -0.08^{NS}	0.316* 0.301^{NS}
Leaf area					0.378* 0.345*	0.345** 0.328*	0.113* 0.107	0.233* 0.193^{NS}	0.158* 0.139^{NS}	-0.1^{NS} -0.1^{NS}	0.144* 0.139^{NS}
Cane diameter						0.205^{NS} 0.192^{NS}	0.052^{NS} 0.047^{NS}	0.039^{NS} 0.026^{NS}	-0.27^{NS} -0.25^{NS}	0.127^{NS} 0.122^{NS}	0.054^{NS} 0.052^{NS}
Sucrose content							0.247^{NS} 0.245^{NS}	0.385^{NS} 0.377*	0.546* 0.531**	0.345* 0.341*	0.557* 0.552**
Brix value								0.624* 0.605**	0.563* 0.554**	0.493* 0.491**	0.395* 0.395**
Wet weigth									0.881* 0.848**	-0.05^{NS} .0003^{NS}	0.072^{NS} 0.072^{NS}
Dry weight										0.336* 0.331*	0.329* 0.324*
Cane weight											0.717* 0.714**

*- Significant, **- Significant at 0.01 level of probability and NS- Non-significant

Table 3. Best subsets regression model for the dependent variable "sucrose%". The best fitting model is shown for a given number of variables beyond one.

Number in model	R-square	Parameters
1	0.0	NLPP, JC
1	3.6	CD
1	5.0	NTPP
1	6.0	BV
1	10.7	LA
1	11.7	CWT
1	14.3	WW
1	17.6	PHT
1	28.4	DW
1	36.0	INLT
2	40.1	NTPP, INLT
3	62.0	NTPP, CD, CWT
4	74.2	NTPP, CD, CWT, WW
5	80.7	NTPP, INLT, CD, CWT, NLPP
6	83.8	NTPP, INLT, CD, CWT, NLPP, PHT
7	85.7	NTPP, INLT, CD, CWT, NLPP, PHT, BV
8	87.7	NTPP, CD, CWT, WW, NLPP, PHT, BV, DM
9	89.0	NTPP, INLT, CD, CWT, WW, NLPP, PHT, BV, LA
10	92.4	NTPP, INLT, CD, CWT, WW, NLPP, PHT, BV, DM, LA
11	93.0	NTPP, INLT, CD, CWT, WW, NLPP, PHT, BV, DM, LA, JC

NLPP, Number of leaves per plant; JC, juice content; CD, cane diameter; NTPP, number of tillers per plant; BV, brix value; LA, leaf area; CWT, cane weight; WW, wet weight; PHT, plant height; DW, dry matter; and INLT, internodal length.

leaves, plant height, leaf area, sucrose content, wet weight and dry matter and Madhavi et al. (1991) found positive association with number of internodes, average internode length and number of internodes. Das et al. (1996) showed that stalk weight was positively correlated with height of millable canes and stalk diameter.

Das et al. (1997) found sucrose percentage in juice was significantly correlated with cane height. Chang (1996) reported that genotypic and phenotypic correlation had the highest value for association between brix and sugar content. The regression ranged from 0.0 to 36.0% for number of leaves per plant and internodal length, respectively, with sucrose on a single factor basis. The remaining R^2 on single factor basis were 0.0, 3.6, 5.0, 6.0, 10.7, 11.7, 14.3, 17.6 and 28.4% for juice content, cane diameter, number of tiller $plant^{-1}$, brix value, leaf area, cane weight, wet weight, plant height and dry matter, respectively. The R-square value increased for 2nd variable model (40.1%) by including number of tillers per plant and internodal length. A further improvement of 62.0% was obtained by including number of tillers per plant and by including cane diameter and cane weight in 3rd variable model. The R-square value increased to 74.2% by the addition of wet weight in 4th variable model by including one variable internodal length in 4th variable model. An increased value of 80.7% was observed in 5th variable model by including again internodal length in 4th variable model. A further improvement of 83.8% values was obtained when plant height was included in the 5th variable model. The variable model showed 85.7% value for R-square by including brix value. Further improvement were exhibited in the R-square values when dry weight, leaf area and juice content included with 8th, 9th, 10th and 11th variables regression model with sucrose percent (Table 3).

The variability for sucrose content on single factor basis was caused by number of tillers per plant; therefore, this character was the most important for increase of the overall sucrose, *Saccharum officinarum* L. However, second variable model exhibited that tillers and internodal length were important traits for increasing overall sucrose in sugarcane.

REFERENCES

Anonymous (2008). Economic survey. Government of Pakistan. Finance Division Islamabad.

Chang YS (1996). Estimating heritability of and correlations among Brix, Purity and Sugar content in sugarcane using balanced multiple location and year data. Report of the Taiwan sugar research institute, 151: 1-10.

Das PK, Jena BC, Nayak N, Parida AK (1996). Correlation and path analysis of cane yield in sugarcane. Coope Sugar 27: 509-512.

Das PK, Parida AK, Nayak N, Maha Patra SS, Jena BC (1997). Path coefficient, regression and discriminate functions in sugarcane. Indian Sugar 47: 31-34.

FAO (1998). Sugar and Sweetener. FAO Production Year Book.

Ghafoor A, Arshad M (2008). Multivariate analyses for quantitative traits to determine genetic diversity of blackgram *Vigna mungo* (L.) Hepper germplasm. Pak. J. Bot. 40: 2307-2313.

Lathrop JE, Alins RE, Smith OS (1985). Variability for yield and yield compounds in I.A.R.I.R. grain sorghum random mating population I. Means, variance comp and heritabilities. Crop Sci. 25: 235-240.

Madhavi D, Reedy CR, Reddy PM, Reddy GLK, Reddy KR, Reddy KHP (1991). Correlation studies in sugarcane. Coope Sugar. 22(6) 379-381.

Panhwar RH, Keerio HK, Khan MA, Rajpoot MA, Unar GS, Mastoi MS, Chohan M, Soomro AF, Keerio AR (2003). Relationship between yield and yield contributing traits in sugarcane (*Saccharum officinarum* L.). Pak. J. Appl Sci. 3:97-99.

Chaudhary RR, Joshi BK (2005). Correlation and Path Coefficient Analyses in Sugarcane. Nepal Agric. Res. J. pp. 24-27.

Singh HN, Singh SB, Chauhan RVS, Vishwakarma RS (1983). Variability for yield and quality in sugarcane. Indian J. Agri. Sci. 53: 786-789.

Steel RGD, Torrie JH (1980). Principles and Procedures of Statistics. McGraw Hill Book Co. Inc. New York, USA.

Sultana T, Ghafoor A, Ashraf M (2007). Genetic variability in bread wheat (*Triticum aestivum* L.) of Pakistan based on polymorphism for high molecular weight glutenin subunits. Genet. Res. Crop Evol. 54: 1159-1165.

Sultana T, Ghafoor A (2008). Genetic Diversity in *ex-situ* Conserved Lens culinaris for Botanical Descriptors, Biochemical and Molecular Markers and Identification of Landraces from Indigenous Genetic Resources of Pakistan. J. Integr. Plant Biol. 50: 484-490.